Master's Thesis Engineering Technology 2018-2019

Comparative life-cycle cost analysis between carbon steel and stainless steel structure for transmission towers

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Introduction & objective

Energy plays a vital role in daily life of the western civilization and transmission towers form the backbone of the energy supply network. These transmission towers are currently being constructed out of carbon steel, a material which is known for its sensitivity to corrosion. Since corrosion endangers the structural integrity of transmission towers, proper maintenance is necessary to ensure its longevity. This study aimed to investigate if stainless steel transmission towers could provide a more economic beneficial solution over carbon steel, when taking account of the entire life cycle.

Materials & methods

Table 1 shows an overview of the materials used in the study:

Table 1: Overview of the used materials during the study [1]

Steel grade	Corrosion resistance	Lifespan of the corrosion resistance
S355J2 carbon steel	No corrosion resistance without coating	The coating protects the steel for 15 years
1.4318 austenitic stainless steel	Good corrosion resistance	The complete service life*
1.4003 ferritic stainless steel	Good for interior or mild exterior conditions	The complete service life*
1.4462 duplex stainless steel	Very high corrosion resistance	The complete service life*

***The complete service life considered in this study is 60 years.**

References: [1] The Steel Construction Institute, Design Manual for Structural Stainless Steel 4th edition, Ascot: Steel Construction Institute publications, 2018.

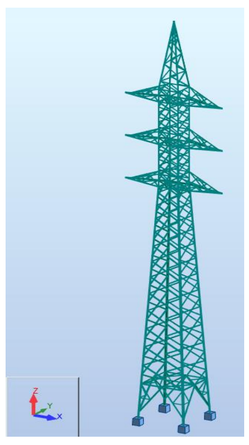

Figure 1: 3D model of the case study

An existing transmission tower was used as case study and modelled in Robot Structural Analysis Professional for 3D analysis, which is shown in figure 1. The design of the carbon structure was done in Robot according to EN1993-1-1. But since Robot did not allow a change to EN1993-1-4, the design of the stainless steel structures was implemented and performed in an excel calculation sheet. Once designed, a Life-Cycle Cost analysis was performed to determine the total costs of each case study. Lastly the study conducted a comparative analysis between all solutions and a similar study conducted in Brazil.

Results

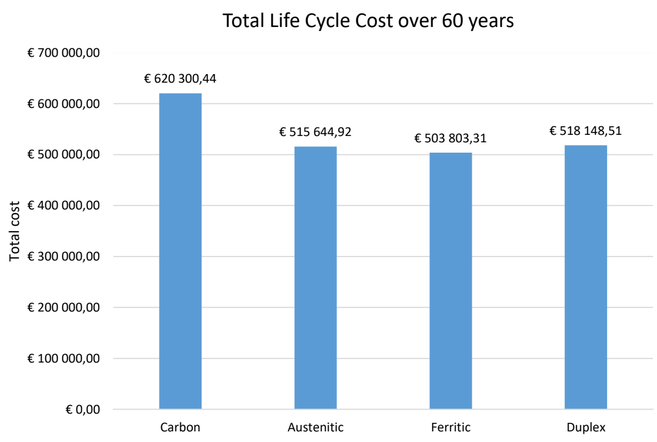

Figure 2: Overview of the total costs per case study

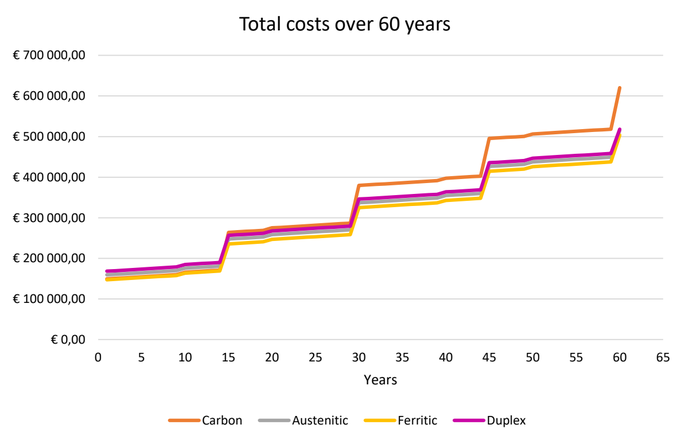

Figure 3: Linear overview of the total costs per case study

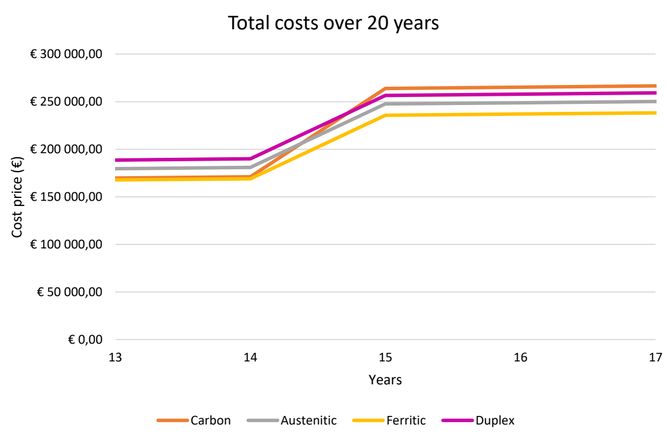

Figure 4: Detailed overview of the total costs per case study

Figures 2, 3 and 4 show the results of the study and indicate that stainless steel can provide a cost reduction up to 19%, when the complete life-cycle is considered. Furthermore it can be stated that the higher initial costs for stainless steel are exceeded after 15 years, from the beginning and 15 years for austenitic-, ferritic- and duplex stainless steel respectively.

Conclusion

The results of the study have proven the potential economic benefits of the use of structural stainless steel over carbon steel, a cost reduction up to 19% could be obtained with a change of material. These results are promising, nevertheless, further investigation is needed to determine more precise costs and to extend the study to other tower configurations. However, since environment is a hot topic right now, it is worth mentioning that the emission of polluting gases derived from the production of stainless steel is lower than with the production of carbon steel, resulting in a lower environmental impact.

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